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Intensities of the Urban Heat Island of Tehran under the Influence of Atmospheric Synoptic Patterns

Pages 55-66

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Introduction: The Urban Heat Island is a phenomenon whereby cities become warmer than the surrounding suburbs. In other words, there is a temperature difference between the cities and their surrounding areas. Generally, the UHI effect is a result of excessive and unplanned growth of urbanization. The behavior of artificial urban texture in terms of absorption of short-wave and long-wave radiation, transpiration, releasing of anthropogenic heat, and blocking prevalent wind is significantly different from that of the rudimentary nature. Hence, the Bowen Ratio in the cities alters and the sensible heat increases. Surface geometry, on the other hand, decreases wind speed in urban regions that plays a significant role in formation of UHI. Since the energy balance inside a city is altered, UHI intensity may change. This means UHI intensity is not spatially and temporally similar in different cities. It must also be noticed that UHI formation in a city usually has diurnal or seasonal patterns which are mostly affected by synoptic weather conditions. There are three main synoptic and local climatology parameters that affect UHI formation: Air Pressure Systems, Cloudiness, and Wind Speed. Under stationary high pressure system conditions temperature differences between urban and rural areas become large. UHI intensity is largest in calm air and cloudless sky conditions and tends to disappear in cloudy and windy weather. Generally, synoptic patterns can be divided into three major conditions as stable, unstable, and mediocre. Unstable conditions reduce the heat island intensity by making turbulences which mix the air. Stable conditions, on the other hand, increase the heat island intensity as they are calm and without air movements. Mediocre conditions can play two roles depending on their characteristics and wind properties. The urban heat island can lead to urban temperatures being 2-5°C higher than those in rural surroundings. Studies have shown the difference in temperature between urban and rural regions (UHI Intensity: \( \Delta T \)) is revealed in minimum temperatures rather than maximums. Henceforth, the Maximum UHI intensity should usually occur after sunsets in urban areas. Other impacts of the Urban Heat Island could be intensifying pollutant concentration over urban areas, altering local wind patterns, increasing humidity, forming cloud and fog, and changing the precipitation rate over a city.

Material and Methodology: In this study, the influence of synoptic weather conditions on the intensities of the urban heat island of Tehran was analyzed. Tehran is the largest and the most populated city of Iran, with an approximate area of 750 Km² and a population of 8 Million during night time. The city lies almost in the middle of the Tehran Province (1882 Km² of area) in the southern side of the Alburz Mountain and is limited to the highlands in northern and eastern parts. On the southern and western parts, it is connected to the flat plains of Varamin, Shahriar and Karaj. To investigate the effects of synoptic weather conditions on the intensities of the Urban Heat Island over Tehran, after a literature reviews, 24 days were selected from the year 2006; two days of each month of the year, one day with the highest and the other with the lowest air pressure over the urban area.

Results and discussion: According to the literature reviews, it was expected that during cyclonic condition the intensity of the UHI would be reduced and inverse condition would be happened in anti-cyclonic condition. Figure 2 represents the variation of the heat island intensities in the study days. As it could be seen, the absolute maximum intensity (8.9 Celsius degrees) has occurred in July while the absolute minimum intensity (1.1) has occurred in January. It can also be seen that the difference between the maxima and minima of heat island intensities have seasonal changes. While the difference between maxima and minima is the least in cold period, it is the most in the warm period. In fact, in the summer the maxima intensities raise more than those of the minima making the difference bigger than what it is in the winter. It should also be noticed that the behavior of the minima and maxima is significantly simultaneous. The maxima and minima almost increase and decrease together. Even in the summer in which the difference is bigger, the maxima and minima are closely correlated. In order to investigate the influence of the synoptic weather conditions on the heat island intensity for all four days, as mentioned previously, the sea level pressure map, wind field and geo-potential height was calculated January: $C$ and
Conclusion: In this study the influence of synoptic weather conditions on the intensities of the urban heat island of Tehran was investigated. The results indicated that the intensity of summertime heat island is higher than that of the wintertime. Furthermore, the correlation between the minima and maxima of heat island intensities shows the influence of the synoptic weather patterns on heat island intensity. In the combined maps it was revealed that the correlation between the maximum and minimum times of heat island intensity is much more significant in the warm period while there are some inconsistencies in cold period. The reason for this condition could be the different patterns of the atmosphere of Iran. In summer, the edge of Azores' subtropical high pressure is located in the midlevel atmosphere of Iran while there are several thermal low pressure cells near the ground. This causes daytime turbulences due to the high radiation income and calm weather when the radiation effect is lessened. However, the condition is almost the opposite in the cold period. In cold period, while there is a cold high pressure condition near the ground, the midlevel atmosphere experiences a relatively active pattern. Due to the passing of westerlies, many unstable synoptic systems pass through Iran's atmosphere. The instability and variety of passing systems increases the wind speed by which the heat island intensity is reduced or undergone variation. Henceforth, the difference between the low level and midlevel atmosphere is the main cause for the variation of the intensities of the heat island of Tehran.
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